Multiple functions with one motor

By Oton Ribic

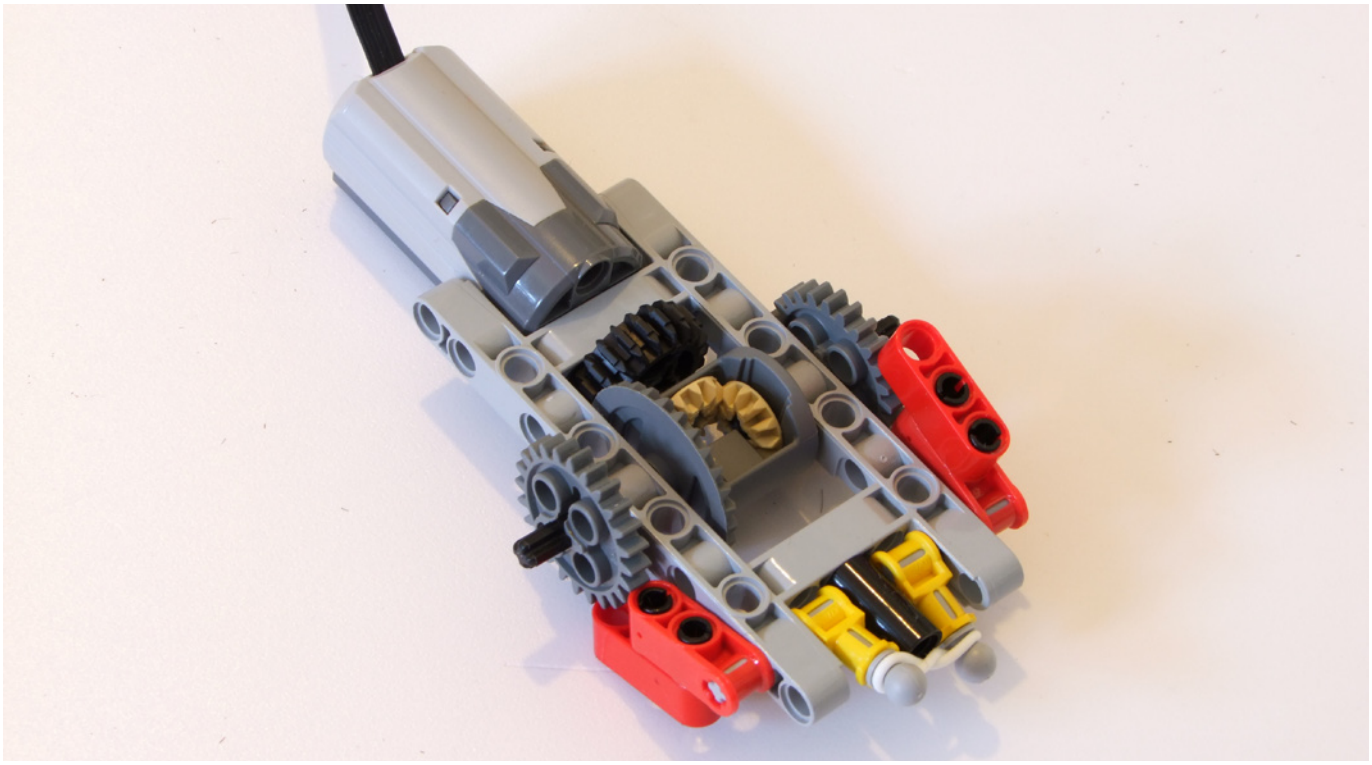
Official LEGO® Technic sets often provide great examples of using manual gearboxes to distribute rotation to various parts of the model, thus allowing many functions to be run by only one motor. Cranes, service trucks and construction vehicles in general show how efficiently one can control many movements using a single motor. On the other hand, many advanced Technic MOC's nowadays have a separate motor for almost each of their functions, often resulting in ten or even more motors and dozens of wires in a single model.

Both approaches have some disadvantages; using gearboxes is clever and efficient, but usually requires direct manual control of the gear levers, making a model impossible to fully control remotely. This does not pose a problem when using a separate motor and an independent remote channel for each function, but that is also complex, large, heavy, and often requires a lot of parts that may not be the cheapest. There is, however, a middle ground — a way to use a single remotely controlled motor for multiple functions, which we will explore in this article.

Going separate ways

The underlying idea of this method is to split the movements of the motor on two separate axles. One is used to deliver the drive (rotation which eventually does the desired work), whereas the other switches the drive among multiple outputs. It is possible to simply split rotational directions with LEGO Technic using a twin ratchet and a standard differential, as shown on the picture. The motor drives a differential master gear, while the differential outputs are equipped with ratchets, each in opposite direction to the other. This simple system is reliable, relatively small, easy to build with standard parts and able to withstand significant loads. If having two separate outputs for two functions is all you need, this little mechanism will do just fine.

However, things become more advanced if there are three or more outputs to choose from — this requires an additional distribution system, i.e. a gearbox that can redirect the input axle to a number of output axles, and lets it be controlled via another axle.



These twin ratchets split the motor motion to two separate axles, one for each direction.

One driver, many followers

There are many designs for such distribution gearboxes. Many of them are based around the idea of an axle sliding lengthwise and meshing with different gears placed around it as it moves, and this is the very approach shown in the example in the photo. Of course, it can be easily expanded to include any number of outputs.

However, for this or any other distribution gearbox design to be suitable for our purpose, it needs to be controlled using just one axle, which will in practice rotate in only one direction. The way around this limitation is to attach it to a crank which is free to rotate a full 360° and is connected off-center to another beam which controls the distribution and passes through all the desired positions as the crank rotates. This may require some fine adjustments, but thanks to the many beam lengths and cranks available today, it is usually no problem.

For example, if a distribution gearbox has four outputs, the control crank will, as it rotates, shift the outputs continuously in the order 1-2-3-4-3-2-1. Obviously, it takes correct timing to set the gearbox to a desired output, but if there is sufficient gearing down (worm gears are especially useful for this purpose), it is relatively easy to do so. Almost any kind of gearbox or transmission which can be controlled with a linear or rotational motion can be adapted to switch outputs through an axle rotating in one direction only.

How far can one go?

Such mechanisms are very useful for controlling peripheral components that don't need to be engaged very often (moveable spoilers on race cars, construction vehicle outriggers, etc.), they are not too large nor do they require particularly rare parts. However, there are some limitations one needs to be aware of before committing to using one in a model.
Obviously, it is impossible to use more than one output function at once. Furthermore, since only one direction is being used for the mechanical work, the receiving components need to be adapted — either to have pullback mechanisms or to be controlled with some kind of a camshaft or crank that normally rotates through full 360°, as mentioned earlier. Take into account, however, that a reverser may be already built into a distribution gearbox as an additional "gear", if there are no other alternatives.

One more thing worth keeping in mind is that, when an output axle is disengaged, most distribution gearboxes will not lock it, and possibly let the component they are controlling move freely. This can be solved by using worm gears that lock a receiver gear regardless, at the expense of speed of operation. Altogether, it may not seem very simple from the text, but in reality, these mechanisms are not any more "sophisticated" than those most Technic builders get acquainted with anyway. So, whether you intend to save weight, reduce the number of large electric components or don't have all the motors you need, give these systems a try.

See the pictured systems in action at www.youtube.com/watch?v=NepNIJpkG7A!
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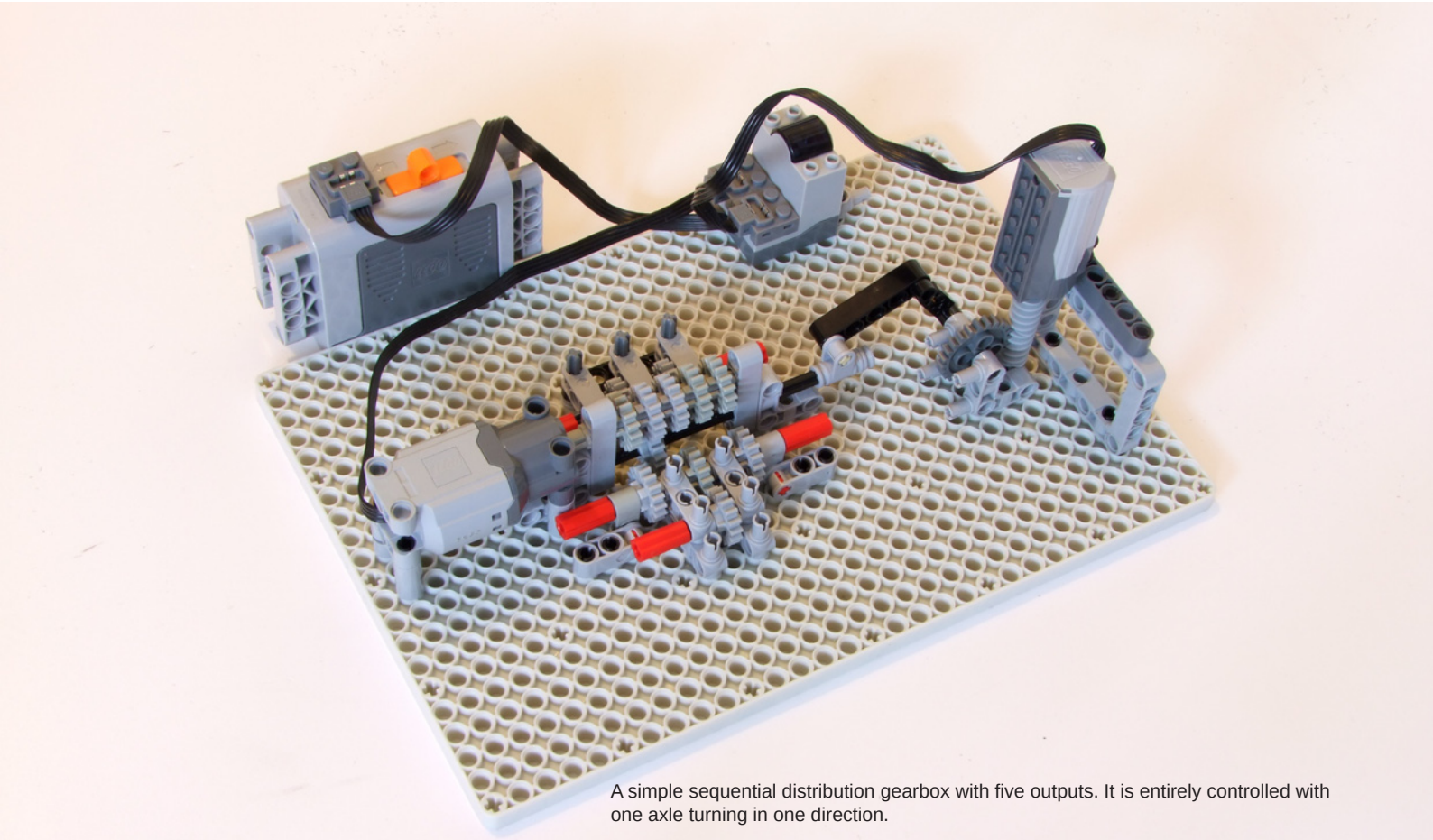
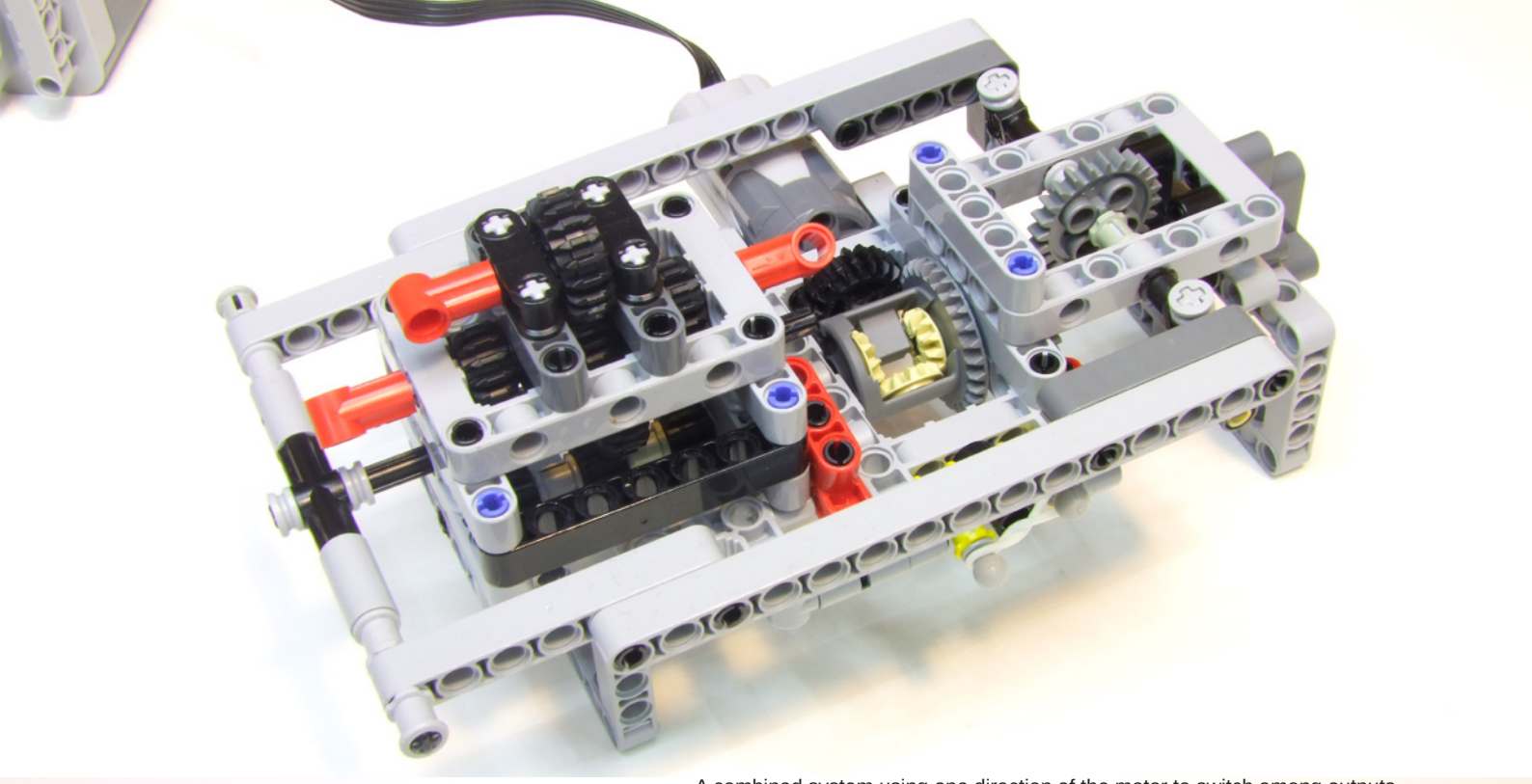
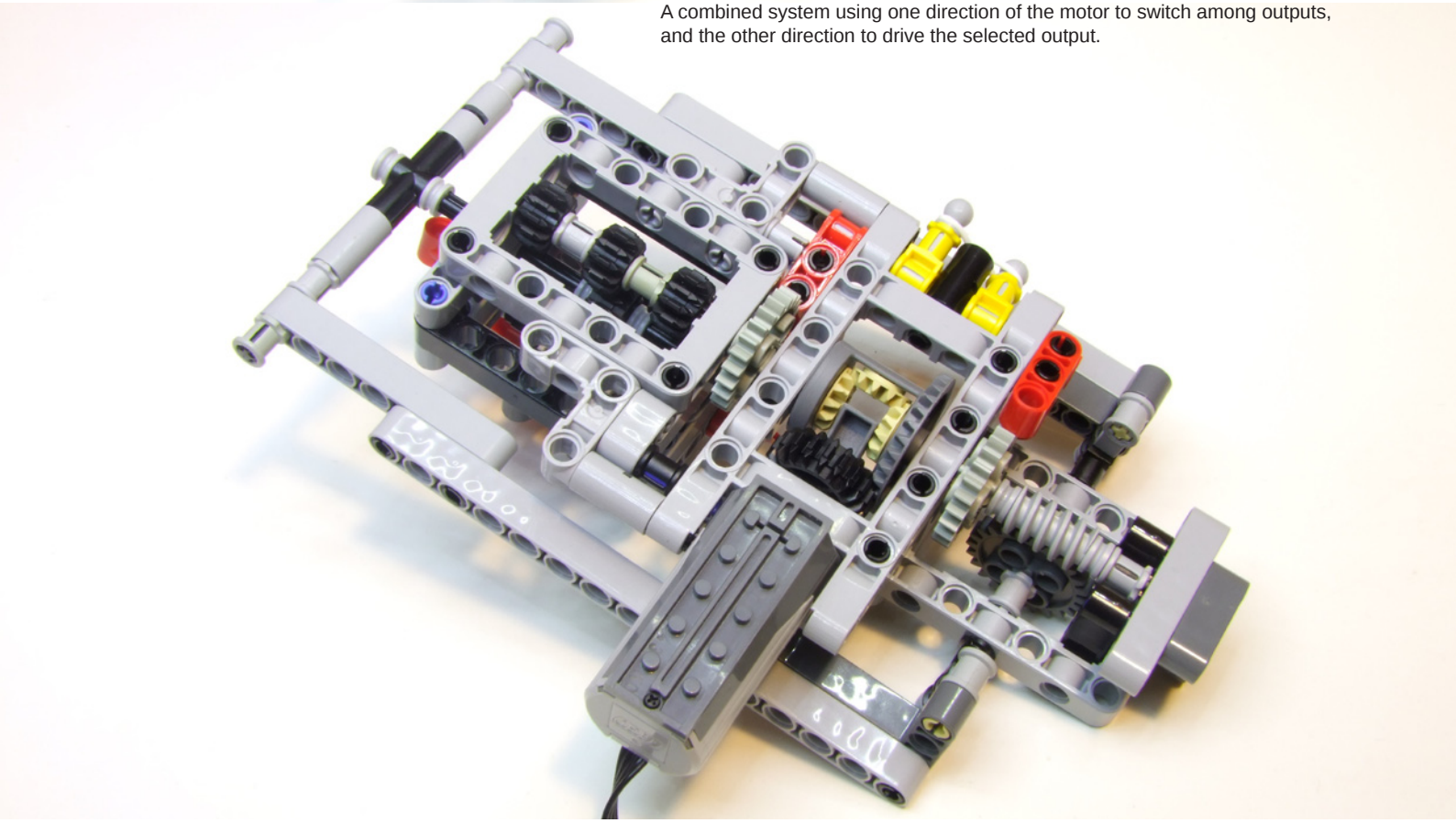


A simple sequential distribution gearbox with five outputs. It is entirely controlled with one axle turning in one direction.



A combined system using one direction of the motor to switch among outputs, and the other direction to drive the selected output.



Controlling multiple functions in a nutshell

- The basic idea is to split the directions of motor rotation to two separate axles, using twin ratchets and a differential, and use one axle to choose the output, the other one to provide drive for the chosen output.
- If only two distinct outputs are needed, a distribution gearbox which lets you choose the output is not required.
- A distribution gearbox and the components connected to its outputs need to be designed in a way that allows controlling them by rotating their input axle in one direction only. This can be done using cranks that rotate full 360° and move an off-center connected beam through all desired positions.
- Locking the outputs that are not currently in use can be done using worm gears; otherwise they will, in most distribution gearbox designs, remain free to rotate.
- Only one output can be engaged at once, and not while the gearbox output is being switched.